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Dye Tracing to Camp Coldwater Spring, Minneapolis, MN

2001 Report by E. Calvin Alexander, Jr., Scott C. Alexander and K. D. Barr

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with Additional Results from:

A Hydrogeological Study of Coldwater Spring, Minneapolis, MN

(by Sophie M. Kasahara, Senior Thesis Project, UM Geoengineering Department, 2016)

(Data Compilation By Betty J. Wheeler, June 2017)

(Photo credit: Hisanao Kasahara, 2015)

Dye Tracing to Camp Coldwater Spring, Minneapolis, MN

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Abstract

Camp Coldwater Spring is a ~6.3 liter/sec spring that emerges from a Platteville Limestone ledge at the top of the west side of the Mississippi River gorge. It was the original water supply for Ft. Snelling in the early-mid 1800's and is a registered Minnesota State Landmark. Potential impacts from nearby highway construction led to two successful dye traces to help define the groundwater basin feeding the spring. These traces are the first traces through the Platteville in the Twin Cities. Dye input trenches were dug with a backhoe to the top of the water table. Input B reached the top of the Platteville and the water table was a few inches above the bedrock surface. Eosin dye input into the trench reached Camp Coldwater Spring, 125 meters away in less than 1.5 hours. The minimum flow velocity in the fractured Platteville Limestone was 83 m/hr. Input C reached the water table while still in glaciofluvial sediments and was 305 meters from the spring. Fluorescein dye from Input C reached the spring in 16 days. The slower flow velocity is a combination of flow through the glaciofluvial sediments and through the fractured Platteville Limestone. These two positive traces demonstrate that Inputs B and C are inside the ground-watershed that supplies the Spring and support concerns about the potential impact of dewatering and construction activities on the Spring. The trace is ongoing.

Camp Coldwater Dye Traces

These dye traces were designed to investigate the possible impact of dewatering and other construction activities associated with the construction of the new Highway 55/62 Interchange on the flow of groundwater to Camp Coldwater Springs. This interchange is in southeastern Minneapolis, Minnesota on the northeast corner of the Minneapolis/St. Paul Airport. Dye tracing can demonstrate that groundwater flows from specific input points to springs, i.e. that those specific input points are inside the ground-watershed that supplies the springs. A positive trace also provides quantitative measures of the groundwater flow velocity between the input point and sampling point under the flow conditions operative during the trace.

Two basic types of samples have been collected and analyzed during this trace: 1) direct water samples (hereafter "water samples") which provide a quantitative measure of the dye present at the time and place the water sample was collected, and 2) activated carbon samplers (hereafter "charcoal samples") which provide a qualitative, integrated record of the passage of dye past the detector during the interval the charcoal sampler is in the water.

Dye Analysis

The concentrations of the fluorescent dyes Phloxine B (CAS 18472-87-2), Eosin Y (CAS 17372-87-1) and Uranine C or fluorescein (CAS 518-47-8) were quantitatively measured with a Shimadzu RF-5000 scanning spectrofluorophotometer. The dyes were measured simultaneously using a synchronous scan mode where the excitation and emission wavelengths are varied with a constant wavelength separation (Dl) of 15 nanometers (nm). Excitation wavelengths are scanned from 385nm to 635nm; emission wavelengths are scanned from 400nm to 650nm at high sensitivity. Bandwidths for emission and excitation are set at 5 nm. Identification and quantification of dye and its concentration is performed using the Peakfit™ 4.0 program (Jandel Scientific Inc.) The detection limits are typically on the order of 10 ppt (parts per trillion, 10^{-12} g/g) or 0.01 ppb (parts per billion, 10^{-9} g/g).

Background Sampling

Background sampling for these traces began on 1 April 2001 at Camp Coldwater Springs and at other locations later in April. The background sampling points include all of the local springs and seeps that careful field work was able to locate, a variable number of monitoring wells, the outfall from a variable number of dewatering wells, and the outfalls from storm sewers and drainage systems. The number of sampling locations grew during the duration of this trace as new sampling points have been added to the array. Automatic samplers were used to periodically collect direct water samples from Camp Coldwater Springs. Charcoal detectors were used to monitor the other sampling points and to back up the direct water samples from Camp Coldwater Springs. No evidence of pre-existing fluorescein, Eosin Y, Phloxine B, or sulforhodamine B was detected in any of the samples during the background sampling. A variety of background fluorescent organic compounds were present in the samples particularly in the charcoal samplers.

Dye Inputs

Input A consisted of pouring 200.2 grams of Phloxine B dye into a collapse feature along the side of the service road. The dye was input at 08:45 CDT on May 8 and was followed by about 2000 gallons of water.

Input B was a 40-foot by 10-foot backhoe trench to the Platteville Limestone bedrock. The trench was 12 to 13 feet deep and had about 3.5 feet of water in the bottom. The water ran into the trench almost as quickly as the backhoe dug through numerous crevices in the bedrock surface. At 17:00 CDT 8 May 2001, 300 grams of 35% Eosin Y Liquid dye (105 grams of dye) was poured into the trench. The contents of a water truck were then discharged into the hole to push some of the dye out of the trench.

The next morning the trench was backfilled with a bulldozer between 10:00 and 10:15 AM, 9 May 2001. The bulldozer operator backfilled the trench too rapidly and some portion of the remaining water and Eosin Y in the trench rose to the surface and a unquantified but small amount of the diluted dye ran a short distance on the surface and then infiltrated. The process of backfilling created a transient, approximately 9-foot high hydraulic

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gradient that pushed some of the dye remaining in the trench, into the groundwater flow system. As discussed below this unplanned event serendipitously provided a signal that was clearly evident at the data at Camp Coldwater Springs.

Input C: Construction dewatering of the area around the new interchange delayed the third dye input at the interchange. A court-ordered 30-day pause in the pumping allowed a trace from the traffic exchange site. Input C was two distinct inputs both within the construction area of the new 55/62 interchange along the western edge of the new bridge. Both were backhoe trenches dug into the water table in glacial sand and gravel. Both inputs used 350g of 35% fluorescein dye solution; 122.5g of dye. The inputs occurred at 06:30 and 07:15 CDT on June 1, 2001. The dyes were mixed with the standing water in each trench and then 2000 gallons of water was added to each trench.

Results Of Anayses Of The Charcoal Detectors

The results of the qualitative analyses of the charcoal detectors are described below.

Input A, Phloxine B: No Phloxine B has been detected on any of the charcoal detectors.

Input B, Eosin Y: Eosin Y began to be detected in the charcoal detectors in and downstream of Camp Coldwater Springs immediately after it showed up in the water on 8 May 2001. It has been detected nowhere else in the monitoring array. The concentration of Eosin Y is currently near its detection limit in the direct water samples from the spring but remains clearly visible in the charcoal detectors.

Input C, fluorescein: Fluorescein began to be detected in the charcoal detectors in and downstream of Camp Coldwater Springs immediately after it showed up in the water on 16 June 2001.

In addition fluorescein has been detected in several of the monitoring wells to the southeast of input points and has been present in the outfall from the dewatering wells near the exchange since they resumed pumping at the end of June.

Results Of Water Analyses

The results of our scanning spectrofluorophotometric analysis of the water samples collected from Camp Coldwater Springs are summarized the breakthrough curve in Figure 1. Dye concentrations are in units of parts per billion (10^{-9} g/g). The breakthrough curves of eosin Y and fluorescein at Camp Coldwater Springs are shown in Figure1.

Input A, Phloxine B: We have not detected any Phloxine dye in direct water samples from the Coldwater Spring crevice or in any of the charcoal detectors.

Input B, Eosin Y: Between 17:30 and 18:30 on 8 May 2001 the leading edge of the Eosin dye began to arrive at Camp Coldwater Springs (Figure 1). The dye had traversed a distance of 125 meters in less than 1.5 hours. Dye concentrations from the original input pulse reached about one ppb. This corresponds to a travel velocity of 273 ft/hr (1.24 miles/day) or 83 m/hr (2 km/day).

A second pulse of dye reached the Camp Coldwater Springs between 11:00 and 11:30 and reached a peak concentration of 7.5 ppb at 13:00 on May 9. The transient head imposed on the system when the input trench for the Eosin Y was filled apparently caused this second pulse. The travel time is consistent with the travel time of the first pulse (about 1.5 hours).

The backfilled trench has apparently produced a long-term source of Eosin Y and, as of early October 2001, Eosin Y continues to emerge from Camp Coldwater Springs.

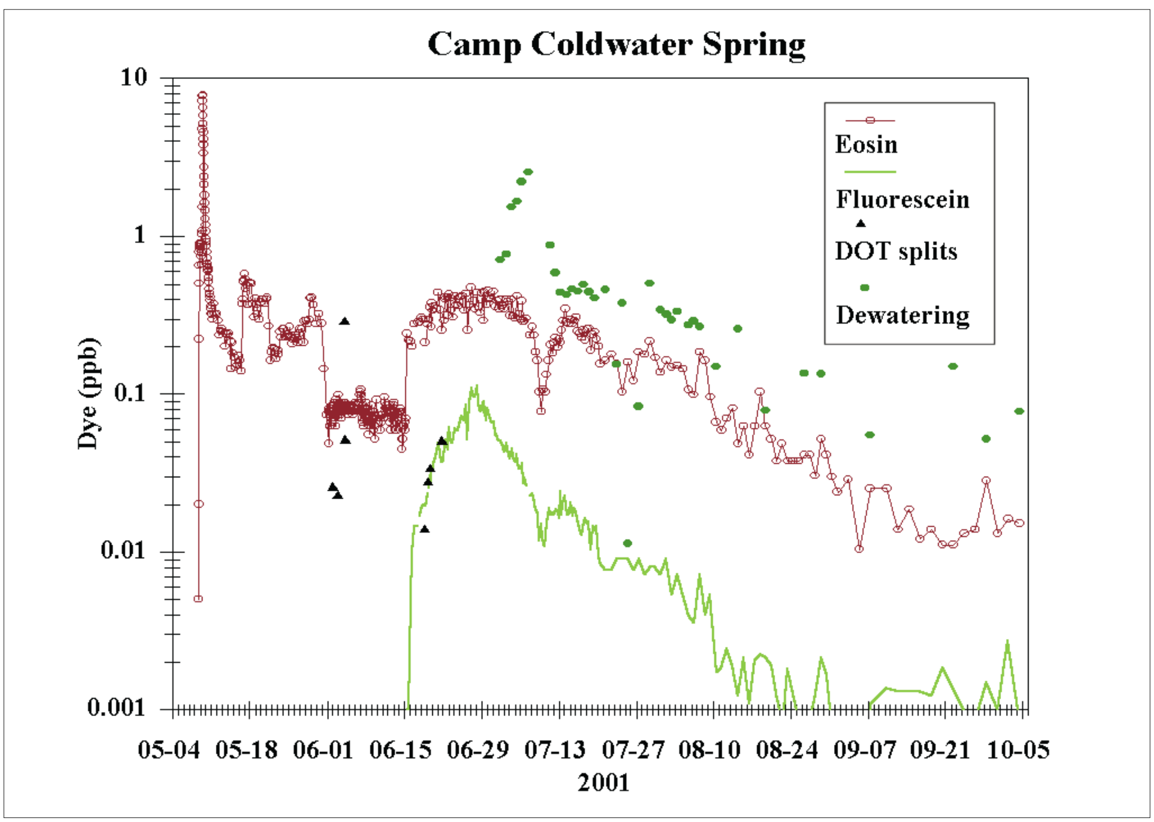

Figure 1. Breakthrough Curve of Dye Samples Collected at Camp Coldwater Spring.

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Dye Trace, cont.

The dye concentration in the direct water samples is near the detection limit but Eosine Y remains clearly detectable in the charcoal detectors, which are currently being changed every two weeks. The long tail contains a potentially useful - but complex and cryptic record - of the flow from input B to the spring.

Input C, fluorescein: Fluorescein was first detected in the water sample collected by the auto samplers at 20:00 on 16 June 2001, sixteen days after it was poured into the pits at Input C, see Figure 1. This corresponds to a travel velocity of 63 ft/day or 19 m/day. Peak concentration occurred on June 27, 2001.

Conclusions

From these results we conclude that dye input Location B and Location C are within the ground-watershed that contributes flow to Camp Coldwater Springs. That conclusion applies to the flow conditions present between 8 May and the present for Input B and to the flow conditions that existed between June 1 and the present for Input C. Under these conditions, dewatering of the area around Location B or C will decrease the flow of groundwater to the springs. Specifically, these results support the concern that the interception of groundwater by a stormwater basin and groundwater subgrade drains associated with the Highway 55/62 interchange will permanently reduce groundwater flows to the springs.

There is also evidence of a groundwater flow component from Input C to the southeast. The dewatering pumping near the exchange is currently impacting both the flow to the southeast and the flow to Coldwater Spring. Pumping will cease this fall. Monitoring of the dye plume will continue as the local flow returns to its previous conditions.

These results are, to our knowledge, the first successful dye traces in the Platteville Limestone in the Twin Cities. The flow from Input B to Camp Coldwater Springs was via some type of high transmissive zone, fracture, or conduit. The leading-edge velocity of 83 m/hr is far greater than any possible flow in porous media. The geophysically determined fractures and karst solution features in the Platteville are obvious candidates for the high velocity pathways and both types of features are known to exist in the Platteville Limestone.

The pathway(s) from Input C to Coldwater Springs is more complex because Input C is in a buried river valley and an unknown part of the pathway from C to the springs was through glaciofluvial sediments. The dewatering pumping that immediately preceded Input C further complicates any interpretation. Nevertheless, the leading edge velocity of 19 m/day is also far in excess of porous media velocities.

The dye trace results not only show that lowering of the water table at C will impact the flow in Coldwater Springs but also indicate that groundwater-flow codes based on laminar flow in porous media are not adequate to model the flow in the Platteville Limestone.

Acknowledgments

These traces were supported by the Minnehaha Creek Watershed District and were conducted in cooperation with Kelton Barr Consulting, Inc.

Editor's Note: The above is modified from a poster presented at the 2001 Midwest Ground Water Conference. Readers interested in further background on the issue of ground water dewatering at the MSP airport and Highway 55/62 interchange may wish to review articles by Stu Grubb, P.G. and Ray Wuolo, P.E., P.G. that appeared in the September 2000 MGWA newsletter (v. 19, no. 3).

MGWA Spring Conference April 23, 2002

Mark your calendars now for next year's spring conference so you won't miss it! We'll be returning to a topic in need of revisiting in light of all the recent technological advances—drilling and field investigation techniques. Welcome spring at the Earle Brown Center and be prepared to "get dirty" with hands-on demonstrations. Watch for more details and registration information in future newsletters and on the website.

MGWA Fall 2001 Conference - The Value of Water

More than 130 professionals attended the conference on November 6 to learn more about the value of water in Minnesota and how value is considered and established.

The morning session introduced those attending to the science of economics and what that discipline has to offer when ground water must be valued.

Steve Taff, University of Minnesota, Applied Economics, provided an overview of the role economics could play when decisions on ground water must be made. He explained that value is attached to a service that ground water provides not ground water itself. Tracking down and attaching dollar amounts to all the tangible and intangible, market and non-market, and in situ and extractive values of ground water is the job of applied economists.

Mark Bjelland, Gustavus Adolphus College, addressed the value of ground water by examining it at the intersection of nature, society, and meaning. From the viewpoint of natural science, water is essential for life, but ground water is also an important part of the hydrologic cycle. Currently, the condition of ground water is being used as a report card on land practices. From the viewpoint of the social sciences, he noted that economic and political power is connected to water and that legal and regulatory structures have been established in response to that power. He remarked that the symbolic meaning of water is often overlooked. To some, the value of water is absolute, not subject to negotiation.

Mary Renwick, University of Minnesota, Applied Economics, discussed valuing water when quality is an issue. She introduced some of the processes, methods, and techniques used to establish values. She referred anyone interested in more detail to the book "Valuing Ground Water: Economic Concepts and

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Figure 1. Eosine dye input into trench (input "B").
Trench was backfilled the morning after dye injection.

Summary Tables of Dye Tracing at (Camp) Coldwater Spring, Minneapolis, MN: 2001 and 2015

2001 Camp Coldwater Study (3 Traces)

(Report from: MGWA Newsletter, v. 20, no. 4, Dec 2001)

This study was supported by the Minnehaha Creek Watershed District, and conducted with the cooperation of Kelton Barr Consulting, Inc.

Input Information								
Date	Time	Input	Site Name	Dye Used	Dye Amount	KFD #	UTMs (NAD 83, Zone	
							Easting	Northing
8-May-2001	8:45	A	Negative Pit	Phloxine B	200.2 grams	MN27:D00003	484,380	4,971,898
8-May-2001	17:00	B	Backhoe Trench	Eosine	300 grams (35 wt. % solution)	MN27:X00008	484,371	4,971,792
1-Jun-2001	6:30	C	TH62/TH55 Interchange	Uranine (fluorscein)	700 grams (35 wt. % solution)	MN27:X00007	484,216	4,971,693

Results						
Sampling Point	Site Name	Analytical Results	Date of Detection (if any)	KFD #	UTMs (NAD 83, Zone	
					Easting	Northing
1	Coldwater Spring	Eosine detected	8-May-2001 (within 2 hrs)	MN27:A00013	484,477	4,971,785
		Uranine detected	16-Jun-2001			

Coldwater Spring 2015 Traces (2 Traces)

Senior Thesis Project by Sophie M. Kasahara, UM Geoengineering Department

This study was partially funded by the National Park Service, and their staff provided some assistance.
Partially funding was also provided by the University of Minnesota's Undergraduate Research Opportunities Program.

Input Information								
Date	Time	Input	Site Name	Dye Used	Dye Amount	KFD #	UTMs (NAD 83, Zone	
							Easting	Northing
6-Jun-2015	10:00	1	VA Med Ctr North Rain Garden (aka, Upper Rain Garden)	Uranine HS (fluorscein)	1,116 grams (35 wt. % solution)	MN27:X00005	483,802	4,972,408
6-Jun-2015	10:35	2	VA Med Ctr SE Rain Garden (aka,Lower Rain Garden)	Sulforhodamine B	1,128 grams (18 wt. % solution)	MN27:X00006	484,048	4,971,891

Results						
Sampling Point	Site Name	Analytical Results	Date of Detection (if any)	KFD #	UTMs (NAD 83, Zone	
					Easting	Northing
1	Coldwater Spring	not detected	---	MN27:A00013	484,477	4,971,785
2	Coldwater Bridge Bug Set 2015	not detected	---	MN27:X00001	484,520	4,971,775
3	Wetland A Gravel	not detected	---	MN27:A00088	484,489	4,971,706
4	Wetland A Bridge Bug Set 2015	not detected	---	MN27:X00002	484,507	4,971,704
5	Small Culvert	not detected	---	MN27:X00015	484,497	4,971,526
6	Big Culvert Bug Set 2014	not detected	---	MN27:X00004	484,541	4,971,488
7	NPS So Drain Pipe Outlet (aka, Big Drain)	not detected	---	MN27:T00002	484,573	4,971,841
8	Hidden Spring	not detected	---	MN27:T00001	484,515	4,972,036

Report Update by
Betty Wheeler and
E. Calvin Alexander, Jr.

Camp Coldwater Spring Dye Trace

at the TH62/TH55 Interchange

Report Updated
14 Jun 2017

Input A:	Location: Sinkhole	Date: 8 May 2001	Time: 08:45 CDT
Sinkhole ID:	UTM E: 484396 *	UTM N: 4971684 *	Investigator: SCA
Tracer A: Phloxine B	WarnerJenkins FDA lot AJ7526 91% dye		Amount: 200.0g
Input B:	Location: Trench	Date: 8 May 2001	Time: 17:00 CDT
Sinkhole ID:	UTM E: 484378 *	UTM N: 4971581 *	Investigator: SCA
Tracer A: Eosin Y	Chromatint Eosin Liquid lot 080498D 35% dye		Amount: 299.8g
Input C (south):	Location: Sump	Date: 1 June 2001	Time: 06:30 CDT
Sinkhole ID:	UTM E: 484214 *	UTM N: 4971462 *	Investigator: SCA
Tracer A: fluorescein	ChemCentral lot 041296 35% dye		Amount: 350g
Input C (north):	Location: Sump	Date: 1 June 2001	Time: 07:15 CDT
Sinkhole ID:	UTM E: 484206 *	UTM N: 4971496 *	Investigator: SCA
Tracer A: fluorescein	ChemCentral lot 041296 35% dye		Amount: 350g

Monitored Sites Location	04/01 04/12	04/12 04/19	04/19 04/27	04/27 05/08	05/08 05/11	05/11 05/14	05/14 05/17	05/17 05/23	05/23 05/29	06/01 06/04	06/04 06/07	05/29 06/15	06/07 06/15	06/15 06/22	07/06 07/13	07/13 07/20	07/20 08/03	08/03 08/17	08/17 09/05
Camp Coldwater Sp 484502E 4971569N *	-	-	-	-	+E	+E	+E	+E	+E	+E	+E	+E	+E	+F +E	/	+++F ++E	++F ++E	+F +E	+F +E
Coldwater Overflow 484569E 4971539N *	-	-	-	-	+E	+E	+E	+E	+E	+E	+E	+E	+E	+F +E	/	++F ++E	+F +E	+F +E	+F +E
Coldwater Shed #4 484504E 4971535N *	/	/	-	-	-	-	-	-	-	-	-	-	-	+E	/	++F ++E	+F +E	+F +E	+F +E
Coldwater Run	/	/	/	/	/	/	/	/	/	+E	+E	+E	+E	+E	/	++F ++E	+F +E	+F +E	+F +E
Coldwater Falls 484758E 4971358N *	/	/	/	-	-	?	?	?	?	+E	+E	+E	+E	+E	/	++F ++E	+F +E	+F +E	+F +E
Cattail Ditch 484531E 4971367N *	/	/	/	-	-	-	-	-	-		/	-	-	-	/	-	/	/	/
Bureau of Mines Sink 484619E 4971629N *	/	/	/	-	-	-	-	-	-	-	-	-	-	-	/	-	-	-	-
Building #9 sump 484454E 4971868N *	/	/	/	/	-	-	-	/	-	/	/	/	/	/	/	-	-	-	-

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Report Update by
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Camp Coldwater Spring Dye Trace
at the TH62/TH55 Interchange

Report Updated
14 Jun 2017

Monitored Sites Location	04/01 04/12	04/12 04/19	04/19 04/27	04/27 05/08	05/08 05/11	05/11 05/14	05/14 05/17	05/17 05/23	05/23 05/29	06/01 06/04	06/04 06/07	05/29 06/15	06/07 06/15	06/15 06/25	07/06 07/13	07/13 07/20	07/20 08/03	08/03 08/17	08/17 09/05
Bike Path Stormwater 484486E 4972073N *	/	/	/	-	-	-	-	-	-	-	-	-	-	-	/	-	-	-	-
OSTP Spring #1 484664E 4971684N *	/	/	-	-	-	-	-	-	-	-	-	-	-	-	/	-	-	-	-
OSTP Spring #2 484649E 4971767N *	/	/	/	-	-	-	-	-	-	-	-	-	-	Lost	/	-	-	-	-
Stormwater Outfall #1	/	/	/	/	/	/	/	/	/	-	-	-	-	-	/	+++F	/	/	/
Stormwater Outfall #2 484797E 4971151N *	/	/	-	-	-	-	-	-	-	-	-	+F	++F	-	/	-	/	/	/
Stormwater Outfall #3	/	/	/	/	/	/	/	/	/	/	-	/	-	-	/	++F	/	/	/
Dewatering #1 484204E 4971532N *	/	/	/	/	-	-	-	-	-	/	/	/	/	/	/	/	/	/	/
Dewatering #2 484153E 4971537N *	/	/	/	/	/	-	/	/	/	/	/	/	/	+F	/	/	/	/	/
Dewatering #3 484090E 4971588N *	/	/	/	/	/	/	/	/	-	/	/	/	/	/	/	/	/	/	/
MW-1 484105E 4971590N *	/	/	/	/	/	/	/	/	/	/	/	/	/	/	-	-	-	-	-
MW-2 484090E 4971588N *	/	/	/	/	/	/	/	/	/	/	/	/	/	/	-	-	-	-	-
PZ-4 484458E 4971438N *	/	/	/	/	/	/	/	/	/	/	/	/	/	++F	+++F	+++F	+++F	+++F	++F
PZ-5 484420E 4971585N *	/	/	/	/	/	/	/	/	/	/	/	/	/	-	-	-	?F	-	-
PZ-6 484419E 4971589N *	/	/	/	/	/	/	/	/	/	/	/	/	/	-	-	-	-	-	-

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Report Update by
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Camp Coldwater Spring Dye Trace

at the TH62/TH55 Interchange

Report Updated
14 Jun 2017

Monitored Sites Location	04/01 04/12	04/12 04/19	04/19 04/27	04/27 05/08	05/08 05/11	05/11 05/14	05/14 05/17	05/17 05/23	05/23 05/29	06/01 06/04	06/04 06/07	05/29 06/15	06/07 06/15	06/15 06/25	07/06 07/13	07/13 07/20	07/20 08/03	08/03 08/17	08/17 09/05
PZ-8 484329E 4971525N *	/	/	/	/	/	/	/	/	/	/	/	/	/	/	-	-	-	-	-
PZ-9 484309E 4971452N *	/	/	/	/	/	/	/	/	/	/	/	/	/	/	-	-	/	/	++F
PZ-10 484308E 4971455N *	/	/	/	/	/	/	/	/	/	/	/	/	/	/	+F	++F	/	/	++F
PZ-11 484326E 4971527N *	/	/	/	/	/	/	/	/	/	/	/	/	/	/	+++F	++F	+++F	+++F	+++F
PZ-12 484450E 4971447N *	/	/	/	/	/	/	/	/	/	/	/	/	/	/	++F	++F	++F	+++F	++F

Legend:

-	negative	B	background	B+	elevated background	L	lost or stolen
+	positive	++	very positive	+++	radiant	*	UTMs: NAD 27, Zone 15
I	installed	/	not sampled	NR	not recovered		
F	Fluorescein	E	Eosin Y	P	Phloxine B		

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